

Linking remotely sensed optical diversity to genetic, phylogenetic and functional diversity to predict ecosystem processes

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ABSTRACT

Remote sensing methods for monitoring biodiversity will be applied to experimental manipulations of plant diversity to examine the linkages between plant biodiversity, soil microbe diversity and ecosystem function at multiple scales of spatial resolution.

PROJECT OVERVIEW

Monitoring biodiversity and understanding its importance for ecosystem processes at regional and global scales are critical challenges, particularly in the face of rapid global change. Measurements of biodiversity are constrained, however, by limited physical and financial resources. Developing less expensive methods to assess biodiversity across multiple spatial and temporal scales will significantly advance biodiversity research. Aerial and space-borne remote sensing offers promise in this regard. Plants display themselves towards the sky in contrasting ways based on their evolutionary history, genetic and chemical composition, physiology, morphology, structure, and phenology, and in the nature of their interactions with the environment. Differences among plants in these aspects can be detected by a combination of optical sampling techniques, including reflectance and chlorophyll fluorescence, allowing remote sensing to assess diversity¹. We are developing methods to test the nature of linkages between optical diversity, plant biodiversity, soil microbe diversity and ecosystem function.

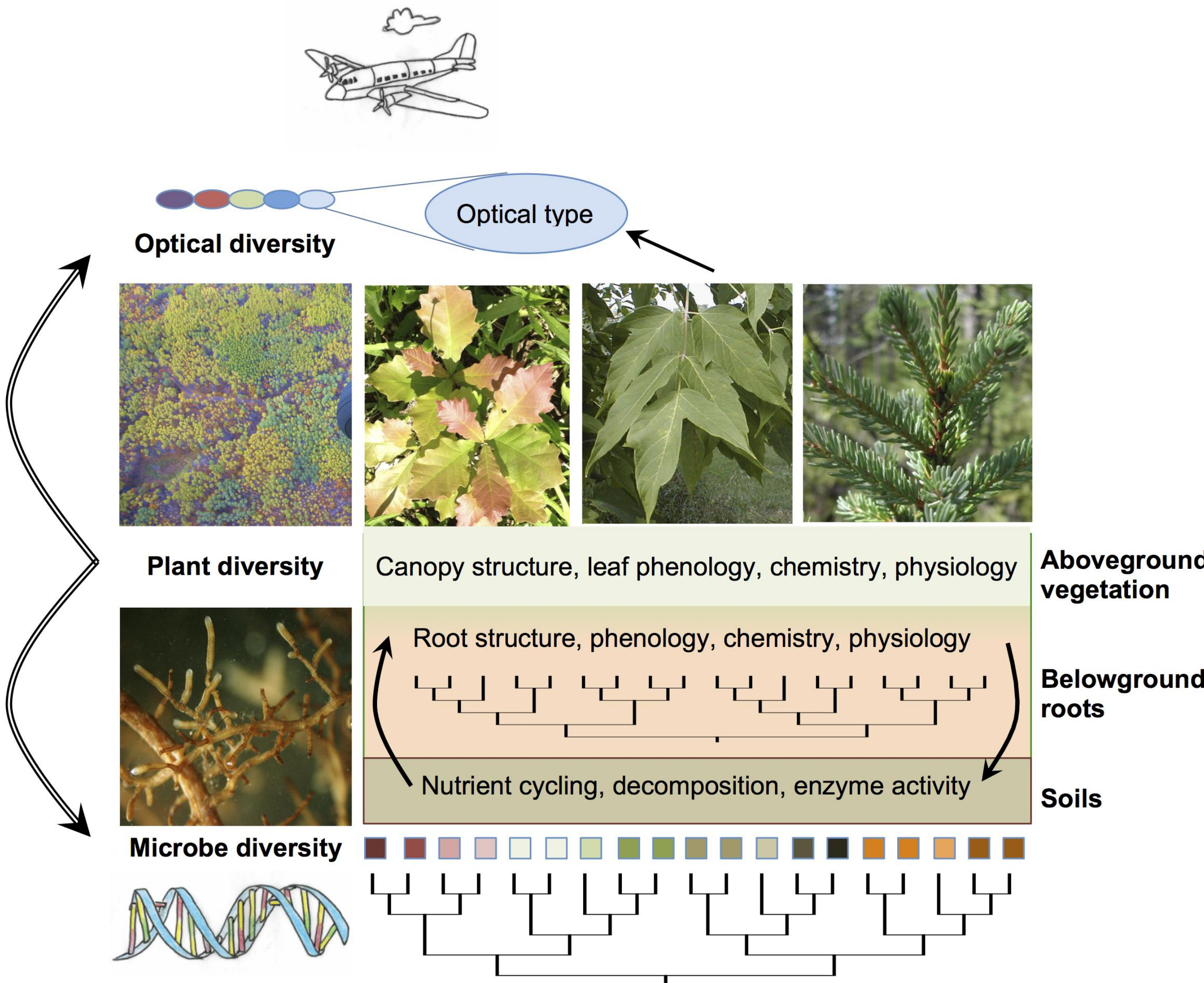
HYPOTHESES

- 1) We expect spectral data and functional attributes at the leaf level to differentiate functional¹ and phylogenetic plant groups² reflecting resource use strategies along the leaf economic spectrum.³
- 2) Contrasting resource use strategies among genotypes, species and lineages provide a basis for detecting contrasting optical types at leaf or canopy scales.
- 3) Optical diversity detected above ground provide key indicators of overall community diversity and ecosystem function.

METHODS

At the Cedar Creek Ecosystem Science Reserve, we will use three biodiversity manipulations that vary genotypes within species, species with different functions and responses to resources, and species from different evolutionary lineages to test whether these kinds of diversity, and their ecosystem consequences, can be detected and measured remotely at multiple spatial scales using reflectance spectroscopy and chlorophyll fluorescence (both PAM and SIF). These efforts will serve in the development of airborne and satellite platforms that can routinely and reliably monitor biodiversity.

A key element of the experiment design involves multi-scale optical sampling (leaf, canopy, and stand-level pixels) from multiple platforms (portable instruments, robotic carts, aircraft, and satellite) to examine the detectability of optical signals at different levels of spatial, temporal, and spectral resolution. Next generation sequencing technologies will be used to describe both plant and soil microbe diversity and allow us to test the concept of surrogacy, such that one metric of biodiversity can be used to provide information about others.



Schematic overview of project illustrating the concept of “surrogacy” in diversity and the hypothesized underlying mechanisms. diversity at one level (e.g., plant diversity), which can be detected optically (optical diversity) translates to diversity belowground (microbial diversity), which can be detected using genomic approaches. Image: J. Cavender-Bares



Cedar Creek prairie diversity plots that vary in species richness, functional diversity, phylogenetic diversity and composition. Photo: Cedar Creek Ecosystem Science Reserve.



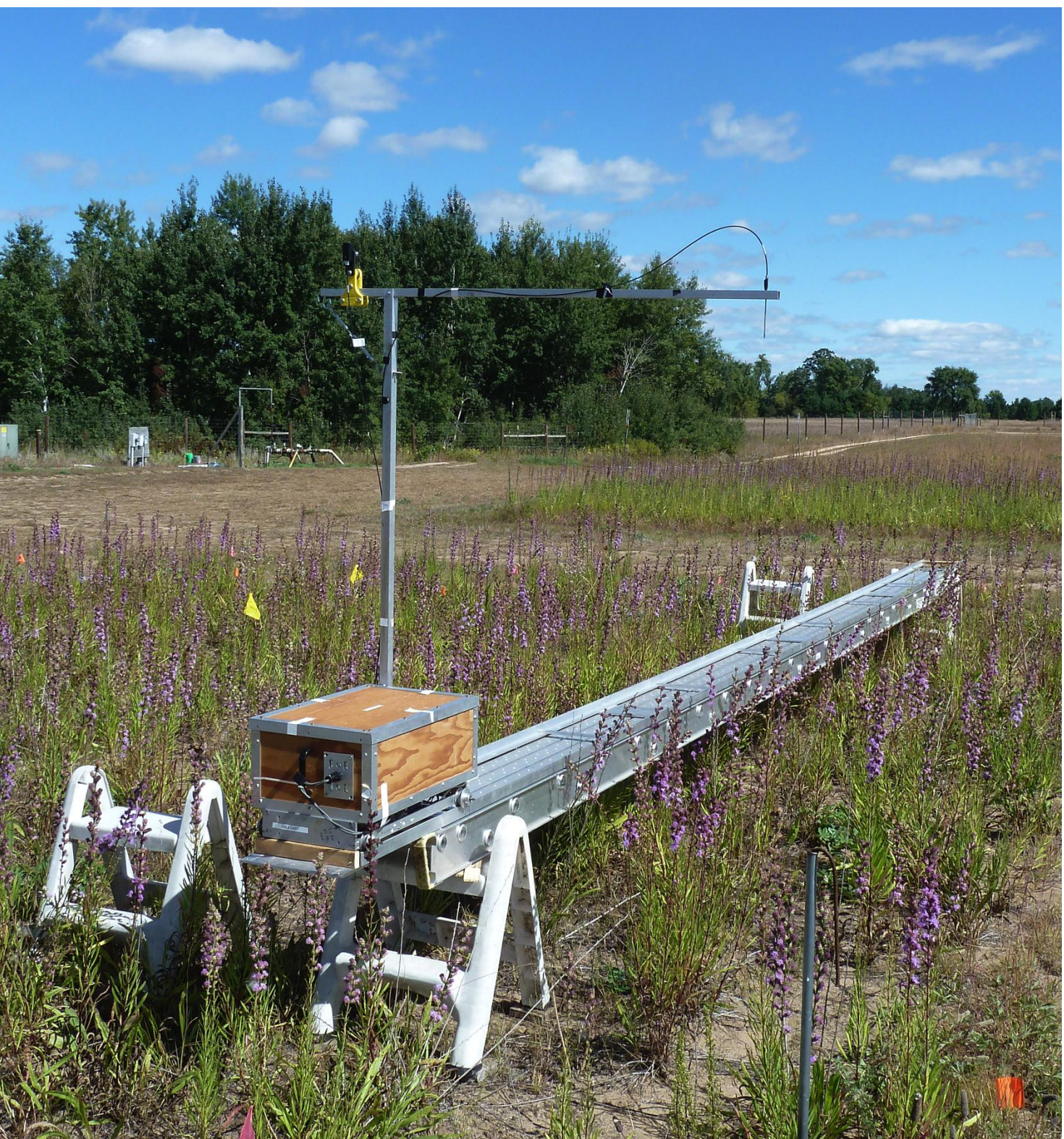
Optical sampling scheme for manipulated vegetation plots at Cedar Creek illustrating rapid transect sampling (above) and detailed sampling (below right) with the use of an automated tram (right).

REFERENCES

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- ³ Wright et al 2004 The world-wide leaf economic spectrum. *Nature*. 428: 821-827.

ACKNOWLEDGEMENTS

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Robotic cart to be used for sampling canopy-level optical properties (reflectance and SIF) in parallel with leaf optical properties (reflectance, SIF and PAM fluorescence). Photo:John Gamon



Aerial photo showing color differentiation of genetically distinct aspen clones. Genotypic differences can be detected via remote sensing techniques. Photo: Mike Madritch